Market-based Approaches to Managing Air Emissions in Alberta

A Discussion Paper

prepared as one of a series of

background materials

considered in the development of

Clean Air Strategy for Alberta.

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EXECUTIVE SUMMARY

Alberta is considering a wide range of options for dealing with air-quality issues. In 1990, the Government of Alberta initiated a public consultation process called the "Clean Air Strategy for Alberta". That process is designed to spur broad discussion of Alberta's air-quality issues, to help define the most pressing problems and to decide how best to control them (Alberta Government 1990). As part of that process, the Clean Air Strategy is exploring opportunities for using market-based approaches in managing emissions more effectively and at lower cost. This paper has been developed to help inform those discussions. It focuses on two particular types of market-based approaches: tradable emission permits and emission charges or taxes.

We begin with the concepts and prior experience, and then apply the lessons to two air-related issues in Alberta:

- acid deposition related to emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x); and
- global warming and emissions of carbon dioxide (CO_2).

The study of acid deposition develops and evaluates a market-based approach to controlling SO_2 (and possibly NO_x) emissions that Alberta could adopt and implement fairly quickly. In the case of CO_2, however, the debate about targets and means of achieving them is at an earlier stage. Perhaps even more importantly, the global nature of the issue makes it critical that Canada act in concert with other nations.

Thus, the analysis of market-based approaches for CO_2 is intended to provide some background information relevant to those larger debates, rather than to design a specific policy instrument that Alberta might adopt.

A. Concepts Behind Market-Based Approaches

The basic concept behind market-based approaches is simple. The government sets overall goals for emissions, but allows market forces to determine the most cost-effective way of achieving those goals. With emission trading, the government sets the total emissions allowed, but then allows firms to "trade" emission allocations. As the result of such trades, emission reductions occur where they cost the least, so that overall societal costs are reduced relative to conventional uniform emission standards that achieve the same environmental goals. Emission charges or taxes work in a similar way. By setting a price on emissions, they provide an incentive for sources to reduce emissions, but do not specify how much specific sources should control, as do conventional emission standards.

1. How Trading Reduces Costs

Emission standards impose high costs for two reason. First, the standards for different source categories typically are based upon the "availability" and "affordability" of control technologies, which creates wide variations among different source categories in the marginal cost of emission control. Second, uniform standards for the sources within a single category (e.g., sour gas sulphur extraction plants) lead to very different costs per tonne controlled; the same SO_2 standard may cost relatively

little per tonne for a large plant with a long remaining life and a sulphur-rich input stream, but much more for a smaller plant that will soon close.

With trading, high-cost sources can buy emission permits from low-cost sources. Buyers and sellers both gain from the flexibility afforded by trading. Buyers (high-cost firms) gain because they can buy the additional permits for less than they save in control costs. Sellers (low-cost firms) gain because they receive more than it costs them to undertake the additional controls. Consumers and the country as a whole gain because these transactions lead to lower overall costs of pollution control, without relaxing the level of environmental protection.

2. Auctions and Taxes

The government may choose to auction permits rather than distribute them to existing sources. With auctions, the overall savings to society remain the same, but the distributional effects are likely to be quite different. Auctions impose significantly higher costs on sources, because they must pay for the permits as well as the control devices. Depending on the market structure, however, the higher costs often will be passed on to consumers in the form of higher prices for the goods whose production creates emissions. In some cases, these higher prices can provide important incentives for consumers to reduce their purchases of such goods.

Emission charges or taxes work in a way similar to tradable permits. Like tradable permits, charges or taxes cause sources to reduce emissions by raising the cost of polluting. The charge or tax rate plays the same role as does the permit price. The primary difference is that in a tradable permit system, the government sets overall emissions by setting the total number of tradable permits available; with an emission

charge or tax it sets the price that sources must pay to emit, but leaves the overall emission level to be determined by market forces.

B. Experience with Emission Trading and Taxes

In concept, emission trading and emission taxes can yield substantial savings in control costs compared to emission standards. Actual experience, however, has been mixed. The largest trading program has suffered from a cumbersome, uncertain and expensive review process, while most "green taxes" have been designed more to raise revenue than to provide appropriate incentives for sources to reduce emissions. Nonetheless, there are important positive examples as well. Both types of experience—the negative as well as the positive—provide useful information for designing effective programs.

1. U.S. Experience with Trading

The actual experience with emission trading—which is limited thus far to the U.S.—includes both clear successes and programs whose performance has fallen well short of their promise. An example of the latter is the set of four "emission trading" (ET) programs developed by the U.S. Environmental Protection Agency (EPA) in the late-1970s, to add flexibility to the existing air pollution control program. (The most widely known of these trading programs is the "bubble" policy; the other three are offsets, netting, and banking.) Virtually every commentator gives the program a mixed review. Total cost savings almost certainly amount to less than 1 percent of air pollution control costs, reflecting the small number of actual trades that have taken place. The major problem seems to be that trading has been very tightly controlled—

the regulations take up 47 fine-print pages—and firms have been concerned that any gains they achieve might be confiscated later through tightened standards or other means.

In contrast, trading for lead in gasoline is widely regarded as a success. In 1982, EPA set a more stringent limit on the amount of lead per gallon but allowed a refiner to produce lead above the limit if it purchased a sufficient number of permits from refineries that produced gasoline with lead below the limit. A provision allowing "banking" for refiners that reduced lead in advance of requirements was introduced in 1985 when the limit was reduced still farther. The combination of the trading and banking provisions generated substantial savings for refiners (and their customers). Moreover, the ability to trade and bank lead appeared to have allowed a faster phase-down of lead, largely because the stringency of the lead standard was not limited by the technical capabilities of certain small refiners.

Programs similar to the lead trading program have been designed for the control of chlorofluorocarbons (CFCs) and acid rain pollutants. The CFC program shows how a scheme can be designed to limit emissions of pollutants from many dispersive uses (e.g., hair spray) by controlling the production and import of the raw ingredients. The limits on production and imports drives up the price of CFC's and leads to a market determination of which uses will decline and by how much. The acid rain program (just passed as part of the new Clean Air Act) shows how a program to control emissions from power plants and other stationary sources can be designed. Both programs appear likely to generate large cost savings; estimated savings

are about 25 percent for the acid rain program and up to 50 percent for the CFC program.

2. Experience with Taxes and Charges

Taxes or charges with at least a nominal relationship to environmental concerns have become increasingly common in many countries, particularly in Europe, and their use is likely to grow. For example, the Task Force on the Environment and the Internal Market created by the Commission of the European Communities has recommended that the community give priority to developing market mechanisms in member countries. However, virtually none of the existing charge schemes is structured to provide incentives to reduce pollution as outlined above.

Most of the charge schemes that are now in place are in fact modest taxes on polluting products that are designed to raise revenues—typically to cover the cost of public treatment or other public expenditures—rather than to provide incentives to reduce pollution and to minimize compliance costs. A German charge scheme for water effluents in place since the mid 1970s offers the major exception to this general rule, though even it serves as a supplement to effluent standards, rather than as a replacement.

3. Implications for Designing Market-Based Approaches in Canada

Perhaps the most important lesson from the U.S. experience with trading is that adding trading after an existing set of standards is in place is unlikely to be fully successful. The ET program became mired in red tape and concerns about "equivalent" trades. In contrast, the lead trading program was adopted when new limits were set, and it was completely integrated into the system. The CFC program

and the acid rain trading programs also are integral parts of their respective regulatory programs.

The primary lesson from the experience thus far with charges and taxes is that if they are to be used to manage emissions effectively—rather than primarily to raise revenues—they must be carefully designed and applied to appropriate targets. More specifically, to provide incentives to reduce pollution (and minimize control costs) a charge or tax should have two characteristics:

- the charge must be based upon the amount of pollution produced (or a close proxy), so that the charge to a firm will be reduced if it generates less pollution; and
- the *charge rate* must be large enough to affect firms' decision-making; small pollution charge rates will simply raise revenue rather than reduce pollution, particularly if they are imposed in concert with a tight standard.

C. Acid Deposition

"Acid rain" has been a major issue in Canada and the U.S. for more than a decade. The primary concern has been that acidic particles formed in the atmosphere from emissions of sulphur dioxide (SO_2) and (to a lesser extent) nitrogen oxides (NO_x) damage lakes and forests. Since 1988, provinces in eastern Canada have been subject to negotiated limits on emissions of SO_2 and NO_x. In the U.S., the new Clean Air Act includes provisions to reduce SO_2 emissions from electric generating stations by roughly 50 percent, and to reduce NO_x emissions by a smaller amount.

At the November 1990 meeting of the Canadian Council of Ministers of the Environment (CCME), the provinces and the federal government agreed to extend the

eastern cap on SO_2 to western Canada. A specific limit—not to exceed 3.2 million tonnes nationwide in the year 2000—will be set after further discussion, as will specific provincial limits. The Clean Air Strategy and other ongoing deliberations within Alberta also will affect the specific limit set by the province.

Because the goal for SO_2 is almost certain to be stated as a cap on total emissions, emission trading is a particularly attractive option. With trading, the province could fix the overall quantity of emissions, assuring that the targets set would be reached. In contrast, if the province were to use an emission charge, the level of emissions would depend on how sources responded. Even with emission standards, the province would not be assured of reaching the target, because standards typically set rates for individual sources; the total emitted depends on the number of sources, their levels of capacity utilization, and other factors beyond the direct control of the province.

1. Design of a Trading Plan

If a trading plan is to assure achievement of environmental goals while allowing trading to proceed freely to minimize costs, responsibilities need to be specified clearly. The basic structure of the plan that we propose may be summarized as follows:

- The program would apply to larger stationary sources of SO_2; the precise criteria for inclusion would have to be specified by the province, but the number of sources involved probably would be 250 or less.

- The province would set an overall emission target for sources included in the plan, reflecting the CCME commitment and other factors.

- The province would allocate the emission target among existing sources, based on historical data (e.g., production levels).

- Sources would be allowed to trade their allotments of emissions and to save unused allotments for future use.

- Sources would be required to monitor emissions and to report all trading transactions, but preapproval of trades would *not* be required.

- To guard against local "hot spots," sources would continue to be subject to the ambient standard for SO_2; trading would replace only the emission standards per se (e.g., percent removal requirements for sour gas plants).

- The province *might* decide to limit trading within some subprovincial regions, to protect particularly sensitive ecosystems or to prevent excessive increases in emissions in certain areas. Alternatively, it might consider broader trading regions that include other western provinces.

2. Likely Performance of the SO_2 Trading Plan

The primary motivation for using market-based approaches generally is to lower the overall costs of meeting environmental goals. Unfortunately, the source-specific control-cost data needed to estimate the cost savings in Alberta are not available. Numerous other studies, however, have estimated savings of 20 percent or more in similar situations. For example, a recent NERA study for Ontario Hydro found that it could save 17 to 31 percent of the costs of meeting NO_X reduction targets if it were simply allowed to trade within its own network of generating plants in southern Ontario. Because the gains from trading are based primarily on *differences* in control costs among sources, these figures understate the likely savings from a broader trading scheme involving a more heterogeneous group of sources. Emission trading also is likely to lower costs by opening up additional methods of emission

reduction (e.g., replacing older plants with newer ones) and by providing greater flexibility for the development and introduction of new control techniques

Emission trading could achieve the same emission-reduction goals as standards, but would provide substantially greater certainty that the goals would be achieved. Emission standards and nontradable operating permits set limits for individual plants, but do *not* provide provincial regulators with a method by which to explicitly manage total emissions; the overall goal may be violated, for example, if industrial activity grows, or older plants are not retired as quickly as expected. In contrast, emission trading fixes the total. Emission trading also may allow faster achievement of environmental goals, because the flexibility offered by trading means that the pace can be based on the capabilities of the average firm; firms that cannot meet the schedule can buy coupons from firms that can go faster.[1] With standards, in contrast, if the government tightens the rules faster than some firms can adjust, it runs the risk of forcing those firms out of business, with attendant economic disruption and visible unemployment.

The overall burden placed on government is likely to change little in moving from standards to trading, but its nature may be different. Emission trading should *reduce* the government's cost of developing rules, because it does not require developing a detailed understanding of the control technologies associated with each source category, as is necessary if reasonable standards are to be set. The resources needed for monitoring emissions and enforcing compliance with trading should be

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[1]The regulator must still be careful, however, not to set so fast a pace that the slower firms are not balanced by firms that can exceed the overall pace.

similar to those needed with standards. On the other hand, administrative costs will *increase* somewhat as the result of the need to operate the trading system and to track holdings. However, these expenses should not be great, and could be covered by a small administrative fee.

3. Extending the System to NO_X

The trading system could be extended to cover NO_X emissions, the other major precursor of acid deposition. Reductions in NO_X also may be based on concerns about ground-level ozone, although Alberta's ozone problems are minimal.

Developing a similar program for NO_X would be straightforward. NO_X sources are much more numerous than those for SO_2, however, so such a program would be somewhat more difficult to administer. A NO_X plan also might be modified to take account of seasonal and locational issues related to ground-level ozone, although earlier NERA analyses of that issue for Environment Canada and for Ontario Hydro suggest that such complications probably are not necessary. If Alberta decided to extend trading to NO_X, it also should consider allowing sources to make trades between NO_X and SO_2.

4. Conclusions and Next Steps

Our analysis suggests that emission trading for SO_2 or NO_X sources in Alberta could offer considerable savings in compliance costs over conventional emission standards, without sacrificing environmental goals or imposing significantly higher demands on provincial regulators. If Alberta agrees that emission trading is promising, the logical next step would be to conduct a more detailed evaluation of legal and administrative questions related to implementation. Assuming that analysis did not

identify any major obstacles, implementation could proceed quite quickly, probably starting with SO_2, and then possibly expanding to NO_x.

D. Global Warming

In half a decade, global warming has gone from relative obscurity—a problem of interest primarily to a small group of specialists—to being the most widely discussed environmental issue in the world. Many nations have made at least nominal commitments to stabilizing or even shrinking their emissions of carbon dioxide (CO_2), the most important of the gases contributing to global warming. Canada has announced its intention to stabilize CO_2 emissions at 1990 levels by the year 2000. It seems likely that whatever strategy is adopted will involve some mix of measures to reduce overall energy use and to reduce reliance on fossil fuels, particularly coal. As the major producer of fossil fuels in Canada and one of its larger consumers as well, Alberta will be greatly affected by such policies.

Much of the current debate about global warming revolves around whether to act now to reduce emissions of CO_2 and other greenhouse gases or to wait until research narrows the enormous uncertainties that surround estimates of the effects of global warming and of the costs of reducing emissions. Our analysis is *not* addressed to those issues. Instead, we focus on analyzing how different market-based mechanisms might be used to achieve whatever targets are chosen through the political process. For purposes of our analysis, we assume that Canada has decided upon some goal for stabilizing or reducing CO_2 emissions—expressed either in terms of a quantity of emissions, or in terms of a price that the country is willing to pay to achieve reductions.

1. CO_2 Emissions and Methods of Reduction

The Intergovernmental Panel on Climate Change (IPCC) estimates that CO_2 accounts for just slightly more than half of the net annual increase in temperature forcing due to greenhouse gases. CO_2 accounts for virtually all of the discussion of potential reductions, however, because CFCs already are scheduled for phase-out, and sources of the other gases are less well understood and appear to be less susceptible to control.

Combustion of fossil fuels accounts for about four-fifths of CO_2 emissions; carbon in the fuel combines with oxygen from the air to make CO_2. Unlike traditionally regulated pollutants—such as SO_2 or NO_X—CO_2 is not amenable to add-on controls to remove it from the exhaust streams from combustion processes. Instead, reductions in CO_2 emissions will come from two basic sources:

- reducing the carbon content of the fuels used, through switching from fossil fuels to non-fossil fuels (such as nuclear, hydro, or other renewables), or from high-carbon fuels (especially coal) to lower-carbon fuels (primarily natural gas); and

- reducing overall energy use through a wide range of means, from more efficient generation of electricity and greater efficiency in end uses, to changes in consumption patterns, shifting the mix towards less energy-intensive goods.

Most studies have concluded that reduced energy use is likely to be the more important of the two general methods, but both will be required if overall costs are to be minimized. Moreover, in contrast to many pollution problems, it seems almost

certain that cost-effective strategies will require a broad array of changes, rather than reliance on any single technological approach.

Conventional standards are unlikely to prove very effective in achieving this efficient mix of actions. The most frequently discussed standards—energy efficiency standards for new vehicles and appliances—deal with only one aspect of the problem. Many of the market-based approaches that have been suggested have similar drawbacks. Allowing firms to trade within sectors to meet efficiency requirements, for example, would increase flexibility *within* sectors, but would not broaden the coverage of those rules. Broad-based energy taxes could provide strong financial incentives to reduce energy use, but would not spur a change in the energy mix toward lower-carbon fuels.

2. Carbon Trading

If the goal is to reduce CO_2 emissions, the most cost-effective incentives will be those targeted specifically on carbon, but with as broad coverage as possible of different sources of carbon emissions. One such approach would be to employ a system of tradable carbon coupons. It would be impracticable to monitor all of the different sources of carbon emissions, but the same effect could be obtained by dealing with carbon in fuel. The government would issue tradable carbon coupons each year equal to the desired level of carbon emissions. To produce or import fossil fuels, firms would be required to submit one coupon for each tonne of carbon in the fuel. Firms would be allowed to trade coupons freely, and to bank unused coupons for use in later years. In addition, the government would rebate coupons to firms that exported fuels; converted fuels to petrochemicals or other uses that did not result in carbon emissions; or "scrubbed" CO_2 from exhaust streams and placed it in long-term

storage. With the exception of credits for scrubbing—which would be exercised rarely, if at all, for the foreseeable future—the system could be administered using records that already are maintained for other purposes.

The coupon system would reduce CO_2 emissions by restricting the total amount of carbon in fuel. As a result of the restriction, the coupons would develop a price. That price then would be reflected in the prices of imported and domestically produced fossil fuels, with larger effects for fuels higher in carbon. Higher prices for those fuels in turn would provide incentives for firms and consumers to switch to energy sources with less carbon (e.g., coal to gas), or no carbon at all (e.g., hydro, wind, or solar). Those higher prices also would encourage firms and consumers to find ways to use less energy, through various improvements in energy efficiency. Higher energy prices also would raise the prices of goods produced using energy, which would lead consumers to shift toward goods that were less energy intensive. These effects also will have implications for Canada's competitive position in world markets.

Depending on how difficult firms and consumers found it to reduce the use of carbon-based fuels, the coupons could become very valuable. Thus, if they were allocated free of charge, as proposed above for SO_2, producers and importers would reap substantial windfalls. It seems unlikely that such a situation would prove acceptable politically. As a result, it seems more likely that the gains to coupon holders would be taken away, either by a tax on the coupons, or by the government auctioning the coupons to begin with, rather than distributing them free of charge.

3. Carbon Tax

A carbon tax would work essentially the same as a carbon trading system. It too could be administered primarily at the producer/importer level, with rebates for exports and the other cases described above. A carbon tax would have the same impacts on firms and consumers as a coupon system in which the number issued yielded the same price as the tax; the prices of carbon-based fuels would rise to reflect the tax. If the coupons were auctioned or taxed, they also would yield the same revenues for the government as a carbon tax. Thus, it seems likely that carbon trading and a carbon tax would be much more similar than one might initially suppose.

The primary difference would arise in how the two different instruments would respond to uncertainty. Carbon trading would set the quantity, but the price of the coupons would vary depending on the actual marginal costs of reducing carbon. In contrast, a carbon tax would set the price, but total emissions would vary with the costs of reduction. For example, if the cost of reducing carbon use proved to be higher than expected, the price of the coupons would go up, while with a tax the level of emissions would be higher than expected. Conversely, if the cost of reducing carbon were lower than expected, the price of coupons would fall, while a tax would achieve a lower emission level. Whether the flexible response of the quantity under a tax is desirable depends on various factors. In the case of SO_2, we argued that such flexibility probably would *not* be desirable, because the goal has been set in terms of a quantity. In the case of CO_2, it is less clear; the costs of reducing emissions are poorly understood, and there may be more willingness to let the emission target (or at least the pace at which it is achieved) be determined in part by how costly it

proves to be to use less carbon. On the other hand, if fixed targets are negotiated internationally, the certainty offered by tradable coupons is likely to be important.

A carbon tax or auctioned carbon coupons both would raise large revenues for the government(s) that imposed them. The distributional effects of the policy and its overall macroeconomic impacts would depend critically on how the revenues were used. Many observers have suggested that the revenues from a carbon tax be devoted to environmental purposes. The other major alternative would be to use the revenues to automatically reduce other taxes. Reducing such taxes would have two major beneficial impacts: it would minimize the negative macroeconomic effects of a tax increase and it could offset much of the negative effect of a carbon tax on the ability of Canadian products to compete in international markets.

4. International Trading

Market-based approaches also might be extended to the international level. Taxes are unlikely to be very viable (who would collect the revenue?), but a form of coupon trading could be used in conjunction with negotiated targets. Some form of international trading—implicit or explicit—seems critical if cost-effective reductions are to be achieved.

Market-based approaches also might be extended to cover other greenhouse gases (such as methane) and sinks of greenhouse gases (such as forests). Ideally such extensions would be integrated with the system used for carbon—based on the relative effects of different gases—but full integration may prove infeasible.

5. Concluding Remarks

Global warming presents policy makers with a series of difficult choices, beginning with the basic question of whether to take action now to reduce emissions or to await better information. Even the best designed economic instruments do not provide an answer to this basic question, or to many of the other dilemmas involved in formulating policies to deal with global warming. Among the most critical of those issues is the coordination of actions internationally, to ensure effectiveness in achieving desired reductions and to minimize adverse impacts on Canada's ability to compete in world markets. However, such instruments—in particular tradable carbon coupons or a carbon tax—offer a cost-effective option for Canada if it decides to stabilize or reduce emissions of CO_2. Both would give market forces maximum flexibility to find the least-cost means of reducing CO_2 emissions; they would not require prejudging what methods of reduction will prove to be most cost-effective, nor even the sectors from which reductions are most likely to come. As a result, they also would allow flexibility over time to accommodate innovations that could lead to lower-cost reductions in the future.